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SUMMARY

Although treatment of bovine spastic paresis cases is often performed using a tibial neurectomy, the potential for substantial economic loss in an older animal, cost of anaesthesia and heightened difficulty of the procedure can preclude its use in veterinary practice. This report describes a tenectomy performed on a 450kg bullock which presented with spastic paresis of the left hind limb. Tenectomy of the medial and lateral tendon of the gastrocnemius muscle provided a good surgical treatment option through a modified incision site in a cranio-lateral approach. Tenectomy has the advantages of being less invasive than a neurectomy, with clearly identifiable landmarks. A key aspect in achieving a successful outcome is to preserve the Superficial Digital Flexor Tendon (SDFT). In the experience of the authors, when compared to tibial neurectomy in similar sized animals, tenectomy had a reduced surgical time and minimized the potential complications such as dropping of the hock.

BACKGROUND

Spastic paresis is a sporadic, neuromuscular disease of cattle affecting one or both hind limbs. A degree of heritability is suspected through a recessive mode of inheritance with low or incomplete penetrance. Although prevalence is low at less than 1% of the cattle population affected (1-5), this will potentially be higher on individual farms if carriers are used as a sire and dams are retained in the breeding herd. Clinical cases along with their dam and sire should be removed from the breeding programme due to the related heritable risk.

Clinical signs usually develop between two and nine months of age. Spastic contractions cause hyper-extension of the hock and stifle affecting the animal's posture and gait (6). The most affected hind limb is held in a caudal position when standing giving a shortened leg appearance, with a swinging motion seen when moving (7). Manual flexion of the affected limb is normal with no resistance or pain found unless remodeling or inflammation of the joint is present, as described in some chronic cases (3). The limb will return to the hyper-extended position, even after completing manual flexion during the clinical examination. A raised tail-head is often reported in clinical cases, likely related to discomfort and/or postural imbalance (8).

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Due to the disease's progressive nature, affected animals often deteriorate with poor growth, muscle wastage and increased recumbency commonly seen leading to euthanasia in chronically affected cases (3, 5, 8). With the average overall steer price in Scotland at 451 p/ kg deadweight (October 2022), this can equate to a loss of £1353 for a 600kg steer killing out at 50% with a deadweight of 300kg (9). Also pain and stress is associated with the muscle spasms involved in spastic paresis, resulting in compromised animal welfare (5). Surgical treatment is a salvage procedure which can help recover some of these costs by getting the animal to slaughter while improving the animal's welfare.

Tibial neurectomy is the main method used for the treatment of spastic paresis, with the aim to surgically transect the tibial nerve innervating the gastrocnemius muscle and hence disconnect the stimulus causing spastic contractions. Tibial neurectomies have a reported success rate of 80% and can be the preferred treatment option within practices particularly where experienced surgeons are present (3). Surgical tenectomy can provide an alternative treatment option to a tibial neurectomy, particularly in heavier animals where tibial neurectomy surgery can be more complicated with the increased muscle depth at the surgical site and the costs of anaesthesia during lengthened surgery. Surgical tenectomy also has a simpler approach with easy to find anatomical landmarks in comparison to a tibial neurectomy. This provides inexperienced veterinary surgeons with a simpler surgical option to a tibial neurectomy.

This report describes the surgical approach to a tenectomy of the medial and lateral tendons of the gastrocnemius muscle in a ten-month-old, 450kg Simmental x Shorthorn bullock. The case discussion reflects on modifying the surgical approach to benefit the surgeon, and potentially improve case prognosis.

CASE PRESENTATION

The 10-month-old, 450kg Simmental x Shorthorn bullock was referred to the Farm Animal Hospital at the Royal (Dick) School of Veterinary Studies on the 29th September 2022, with suspected spastic paresis of the left hind limb, with clinical signs reported at five months of age. The bullock originated from a 100 cow suckler farm based in South East Scotland, using predominantly Simmental and Beef Shorthorn breeds. The farm reported one case of spastic paresis per year in homebred calves, with two cases related to the same bull on farm. Spastic paresis was confirmed during clinical examination with the left hind limb extended caudally while standing giving a shortened leg appearance. This is shown in Video 1, also showing hyperextension of the right hind leg (excessive straightening at the hock when standing). This is common with spastic paresis cases with the majority bilateral in nature, but with one leg significantly worse in appearance. The excessively straight appearance of the right hock joint may have been related to altered weightbearing due to the severity of the presentation of the left hind leg. The hock was able to be flexed during examination, using a rope while the animal was restrained in the crush, with no evidence of pain or excessive synovial fluid during manipulation. The rest of the clinical examination was unremarkable.

The animal's welfare was deteriorating from when initial clinical signs were first suspected at five months of age, with increased lying times and wastage of the gluteal biceps muscle in the affected left hind limb now observed. The severity of the clinical signs and the negative effect on the animal's welfare made this animal a suitable candidate for referral and potential surgical treatment. As the animal was not to be retained for breeding, the aim

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was to undertake a salvage procedure that would enable the animal to reach acceptable slaughter weight.

INVESTIGATIONS

Not relevant

DIFFERENTIAL DIAGNOSIS

Upward fixation of the patella
Tetanus
White muscle disease (Selenium/Vitamin E deficiency)
Osteochondrosis dessicans
Gonitis (Arthritis of the stifle joint)

TREATMENT

On the 27th of October 2022, a tenectomy of the superficial tendon of the medial head and deep tendon of the lateral head of the gastrocnemius muscle was performed under general anaesthesia in a clean straw bedded pen.

The bullock was fasted for 12 hours prior to surgery. A 14-gauge catheter was placed in the left jugular vein for intravenous access prior to surgery. Parental antibiotics of 8mg/kg procaine penicillin and 10mg/kg dihydrostreptomycin (Pen&Strep: Norbrook) and non-steroidal anti-inflammatory drugs of 0.5mg/kg meloxicam (Metacam: Boehringer Ingelheim) were administered prior to surgery. The animal was sedated with 0.13mg/kg bodyweight of xylazine (Rompun 2% solution: Elanco) and once recumbent was given 2.22mg/kg of ketamine (Ketamidor: Chanelle Pharma) to induce anaesthesia. A caudal epidural was administered using 40ml of Procaine Hydrochloride (Pronestesic: Fatro). Maintenance of anaesthesia during surgery was carried out using a continuous intravenous infusion of sodium chloride, ketamine and xylazine. A one litre bag of 9mg/kg sodium chloride (Aqupharm 1: Animalcare) combined with 1500mg of ketamine and 50mg of xylazine was used in a continuous intravenous infusion to maintain anaesthesia during surgery. The surgical procedure lasted approximately 45 minutes, starting with an infusion rate of 3ml/kg/hr, then titrating to effect.

A 7-10cm incision was made over the cranio-lateral aspect of the calcanean (or Achilles) tendon, starting 7cm above the point of the hock. The subcutaneous tissue and fascia surrounding the SDFT, medial and lateral gastrocnemius tendons was bluntly dissected parallel to the tendons. Once the three individual tendons were found, they were then traced proximally and distally within the incision to find their likely point of origin and point of insertion. The SDFT that was to remain intact was clearly identified, originating between the gastrocnemius tendons proximally before passing medially to the medial head of the gastrocnemius tendon and capping the calcaneus distally. A tenectomy was performed on the superficial tendon of the medial head and the deep tendon of the lateral head of the gastrocnemius muscle. Each tendon was elevated separately and a 2cm section of each tendon removed. Contrary to the approach described in some studies, the tendinous calcaneal sheath of the deep tendon of the lateral head of the gastrocnemius muscle was also incised, in a simplified surgical approach (7). The subcutaneous layer was sutured using a continuous pattern while the skin was closed using a cruciate pattern using absorbable vicryl (3 USP, Ethicon).

The animal was monitored closely in the hours after surgery until sternal recumbency could be maintained without falling over into lateral recumbency, to prevent bloat. The

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slow recovery in this case may be related to the continuous intravenous infusion proceeding until the completion of skin sutures. The pen was also kept deeply bedded with straw to allow steady footing after surgery. The animal was able to stand for short periods the following day post-surgery, standing to eat and drink for up to 10 minutes at a time. 24 hours post-surgery, hyper-extension of the left hind limb was no longer present. The animal becoming more active in the pen from two days after surgery and time spent lying reduced over the following week. Video 2 taken seven days post-surgery shows the normal position of the left hind limb. Post-operative medical management was carried out while the animal was in the locking head yoke within its pen to limit the stress of handling on the animal. Meloxicam (Metacam: Boehringer Ingelheim) at 0.5mg/kg was administered for a final time on the third day post-surgery. Parental antibiotics of 8mg/kg procaine penicillin and 10mg/kg dihydrostreptomycin (Pen&Strep: Norbrook) had been continued daily for five days post-surgery. Daily visual assessments were also carried out from outside the animal's pen in order to minimize disturbance to the animal's recovery, with no signs of infection or swelling at the surgical site. Once the animal was weight bearing soundly, it was transported back to the farm of origin 14 days after surgery.

OUTCOME AND FOLLOW-UP

After return to the farm of origin, the animal was kept outside in a paddock with two other cattle of similar age. An on-farm follow-up visit was carried out on 6th December 2022, forty days after the tenectomy operation. The animal no longer hyper-extended the left limb allowing a normal posture and improved gait. The improved mobility seen in the animal at forty days post-surgery should allow continued growth and weight gain, with the goal to get this animal to slaughter weight. With the animal now in a fit condition, the owner was to shortly sell this animal to a finishing unit where it could be fattened in a pen with other animals.

DISCUSSION

Tenectomy of the superficial tendon of the medial head and the deep tendon of the lateral head of the gastrocnemius muscle, whilst preserving the SDFT, provides a suitable alternative for veterinary surgeons in practice in comparison to tibial neurectomy which is more widely reported in the literature (8, 10). A success rate of 80% has been reported following partial tibial neurectomy surgeries (3). Electro-stimulation can be used during surgery to correctly identify the tibial nerve branches, with the importance of previous surgical experience within the veterinary team shown to be a determining factor in preferring this approach (10). Total tibial neurectomy is more commonly carried out in general practice due to the difficulty of electro-stimulation and the lack of clear evidence of its increased efficacy, or to what extent it may reduce post-surgical complications such as gastrocnemius rupture. Surgical tenectomy with preservation of the SDFT has also been reported to have high success rates, with 8 out of 8 cases having a good surgical outcome in one study (7). In practice, one of the main challenges faced by the veterinary surgeon during tibial neurectomies is inexperience where anatomical landmarks can be difficult to find, with variation seen in their description in the literature (3, 11). At the Farm Animal Hospital at the Royal (Dick) School of Veterinary Studies, tibial neurectomies are carried out with an experienced large animal surgical diplomate holder with plenty of assistance available during the surgical procedure in a specialist large animal operating theatre. This is to overcome the difficulties faced during surgery with finding the correct incision site and managing the thick muscle layer within the incision, with extra help and retractors commonly needed to hold the incision open to allow differentiation of the tibial and

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peroneal nerves via electro-stimulation. This specialised equipment can be burdensome for field surgery and unlikely to be available to all practitioners in rural practice.

Tenectomy of the superficial tendon of the medial head and the deep tendon of the lateral head of the gastrocnemius muscle while preserving the SDFT, provides a good alternative to the challenges faced in a tibial neurectomy. Landmarks for the incision site are easy to find, with tendons lying superficially below to the incision. Help is not required to hold the incision site open with surgical time commonly less than that required for a tibial neurectomy. The modified incision site starting 1cm above the point of the hock allows the SDFT to be more easily identified as it caps the calcaneus and reduces the risk of incising the lateral saphenous vein (Figure 1b). Guidance on how to clearly identify the structures involved during surgery are not clearly reported (3, 12), with the aim of this article to make landmarks easier to find and discuss what the authors' might do differently in future cases.

Figure 2 illustrates the anatomy of the SDFT and how it can be differentiated from other structures during surgery. The SDFT originates proximally between the medial and lateral heads of the gastrocnemius muscle then winds medially to the superficial tendon of the medial head of the gastrocnemius muscle, to then spread and cap the point of the hock (12).

Therefore, the two ways to clearly identify the SDFT are by finding:

- where the SDFT passes medially to the superficial tendon of the medial head of the gastrocnemius muscle (proximal in incision site)
- the tendon capping the calcaneus, as this will be the SDFT (distal in incision site)

In the authors' experience, finding the tendon capping the calcaneus is the simplest and most definitive method in distinguishing the SDFT (complimented by additional experience with cadaver surgical practice). Maintaining the structural integrity of the SDFT is important in surgical correction of spastic paresis cases, as dropping of the hock (hyperflexion) has been reported as a possible complication (7, 8, 11, 13). Hyperflexion of the hock occurs immediately after surgery when the structural integrity of the SDFT is affected, with reliance on the tendon ends to knit together when healing over 4-6 weeks, to allow limb positioning to return to a normal position (8). Both tibial neurectomies and tenectomy of the medial and lateral tendon of the gastrocnemius muscle have a risk of hyperflexion through rupture of the gastrocnemius muscle (3). One study reported an incidence of 4% for a ruptured gastrocnemius muscle post-surgery in tibial neurectomy cases causing hyperflexion of the hock, while although mentioned as a post-surgical complication, hyperflexion of the hock or rupture of the gastrocnemius muscle after tenectomy of the medial and lateral tendon of the gastrocnemius muscle has not been clearly reported, with one small study having no post-surgical complications with dropping of the hock (7). Care should also be taken to avoid the lateral saphenous vein during surgery as seen in Figure 2a. The modified surgical site, shown in Figure 1b, will help in avoiding the lateral saphenous vein which runs proximal to the incision while providing good access to the tendons of interest. In addition, the more proximal the surgical incision is made, this increases the likelihood of accidentally incising the lateral saphenous vein.

The one minor challenge that occurred during the tenectomy surgery was manipulation of the deep tendon of the lateral head of the gastrocnemius muscle during surgery. In the case described, the authors felt the incision was made too proximal and too caudal following current published advice. This led to the deep tendon being more difficult to cut due to its

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deep location within the surgery site, and the deep tendon being cut more proximally giving a more muscular appearance than if it was cut more distally (Figure 1a). Although the surgical outcome was still good in this case, the speed of surgery may be improved using the recommended surgical site (Figure 1b), with easier access to the tendons involved in this procedure (authors' experience through cadaver surgical practice).

The surgery performed had a good surgical outcome, with the animal's welfare much improved. The pain involved with the muscle spasms in spastic paresis had been resolved following the surgery, improving the welfare of the animal. This was seen 40 days post-surgery (Video 3) through the animal's demeanour, with the animal looking bright and spending more time moving on its feet than prior to surgery. The animal's gait post-surgery was different to normal in the left hind leg, but most importantly the animal was weight bearing on all four legs and moving without pain.

In this case, the authors sedated the animal with xylazine, induced anaesthesia with ketamine and then maintained anaesthesia during surgery using a continuous intravenous infusion containing sodium chloride, ketamine and xylazine. A caudal high-volume epidural was also performed. As this was one of the first cases of spastic paresis the authors had treated using a tenectomy, the aim of the anaesthetic protocol was to provide 45-60 minutes of surgery time. The general anaesthesia in this case was satisfactory, with the aim of the low dose of xylazine in the continuous intravenous infusion to provide additional analgesia while counteracting the increasing skeletal muscle tone effect of ketamine.

However this would not have been suitable for patients with respiratory or cardiovascular disease given the use of xylazine in both the sedation and continuous infusion. This could have potentially led to severe hypotension, respiratory depression and anaesthetic complications. Use of ketamine in continuous rate infusions in cattle has been described as safe and would be an alternative to using both xylazine and ketamine in a continuous infusion (14). This intensive anaesthetic protocol used may have been a factor in the slow recovery seen in this bullock post-surgery.

As the authors are now experienced in this tenectomy approach, a shorter anaesthetic protocol would be sufficient. A recumbent dose of xylazine 2% with a caudal high volume epidural (1ml per 10kg local anaesthetic) would provide up to 30 minutes of surgical time. Ketamine (with or without xylazine administered at a third of the initial dose) could then be an option if required to help finish the surgery.

In the authors' opinion, tenectomy was the preferred surgery as it allowed a reduced surgical time under field conditions and in a heavier animal kept the cost of anaesthesia economically justifiable. The modified surgical technique allows easier identification of the tendons when the incision is started closer to the point of the hock, with less risk of incising the lateral saphenous vein. Incising the tendinous calcaneal sheath of the deep tendon of the lateral head of the gastrocnemius muscle also allowed a simplified surgical approach with no issues such as hyperflexion of the hock. With few reports described on the tenectomy of the medial and lateral tendons of the gastrocnemius muscle, this prompted the authors' enthusiasm to report this case with modifications in the surgical technique to simplify the procedure. This has a distinct advantage over tibial neurectomies where the anatomy of interest is more accessible. This can be beneficial in practices where there is

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little previous experience in spastic paresis surgery and where animals are presented at a heavier, older age. The described tenectomy approach used in this case provides a suitable treatment option in heavier patients with a good surgical outcome.

LEARNING POINTS/TAKE HOME MESSAGES

1. Tenectomy can be used to improve the welfare and performance of cattle with spastic paresis
2. Tenectomy of the medial and lateral tendon of the gastrocnemius muscle can be a useful alternative to a tibial neurectomy especially in older, larger animals
3. Maintaining the structural integrity of the SDFT is important

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as this is a single case report detailing a clinical case managed in keeping with the RCVS (Royal College of Veterinary Surgeons) professional guidelines.

FUNDING STATEMENT

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AUTHOR CONTRIBUTION STATEMENT

DS McFarland, TS Woods and RF Kelly managed the case, performed the tenectomy surgery and associated anaesthesia.

DS McFarland, TS Woods, AI Macrae and RF Kelly wrote the manuscript

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FIGURE/VIDEO CAPTIONS

Figure 1a: This image shows the muscular appearance of the deep tendon of the lateral head of the gastrocnemius muscle when cut proximally. **Figure 1b:** shows the incision site (as indicated by suture line) and the preferred incision site (black line) that would allow easier location and manipulation of the deep tendon of the lateral head of the gastrocnemius and the superficial tendon of the medial head of the gastrocnemius muscle.

Figure 2a: Dissected version of surgical area with landmarks. (A) Superficial tendon of the medial head of the gastrocnemius muscle. (B) Superficial digital flexor tendon. (C) Deep tendon of the lateral head of the gastrocnemius muscle. (D) Lateral saphenous vein. (E) Calcaneus. **Figure 2b:** The superficial tendon of the medial head of the gastrocnemius muscle and the superficial digital flexor tendon can look similar during surgery, and were distinguished using the methods described above. Note in this incision that was made proximally, how the location of both tendons changes in comparison to their distal location seen in Figure 2a.

Video 1: Pre-surgery, note the hyper-extended position of the left hind limb

Video 2: Seven day post-surgery, note the normal position of the left hind limb

Video 3: Forty days post-surgery, note the ability to weight bear on all four limbs, with no associated pain

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OWNER'S PERSPECTIVE

IMAGE QUIZ

The SDFT originates proximally between the medial and lateral heads of the gastrocnemius muscle then winds medially to the superficial tendon of the medial head of the gastrocnemius muscle, to then spread and cap the point of the hock

Image/Figure 2a

MULTIPLE CHOICE QUESTION

What is the main method for identifying the superficial digital flexor tendon (SDFT) during surgery?

POSSIBLE ANSWERS TO MULTIPLE CHOICE QUESTION

A. Identify where the SDFT passes medially to the superficial tendon of the medial head of the gastrocnemius muscle (proximal to in the incision site)
B. Identify which tendon is capping the calcaneus, as this will be the SDFT (distal to the incision site)
C. Identify which tendon is capping the calcaneus, as this will be the medial tendon of the gastrocnemius muscle (distal to the incision site)
D. Identify where the SDFT passes laterally to the superficial tendon of the medial head of the gastrocnemius muscle
E. Identify which tendon is capping the calcaneus, as this will be the lateral tendon of the gastrocnemius muscle (distal to the incision site)

CORRECT ANSWER

A and B. The SDFT originates between the gastrocnemius tendons proximally before passing medially to the medial head of the gastrocnemius tendon and capping the calcaneus distally.

PLEASE SAVE YOUR TEMPLATE WITH THE FOLLOWING FORMAT:

Corresponding author's last name and date of submission, e.g.,

Smith_June_2017.doc

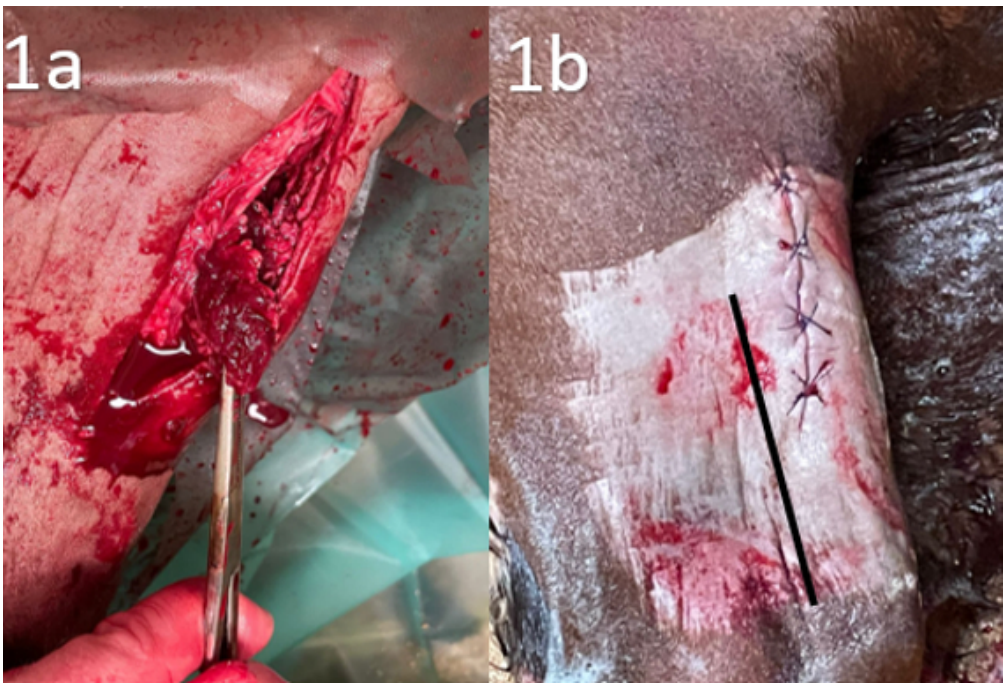

Figure 1a: This image shows the muscular appearance of the deep tendon of the lateral head of the gastrocnemius muscle when cut proximally. Figure 1b: shows the incision site (as indicated by suture line) and the preferred incision site (black line) that would allow easier location and manipulation of the deep tendon of the lateral head of the gastrocnemius and the superficial tendon of the medial head of the gastrocnemius muscle.

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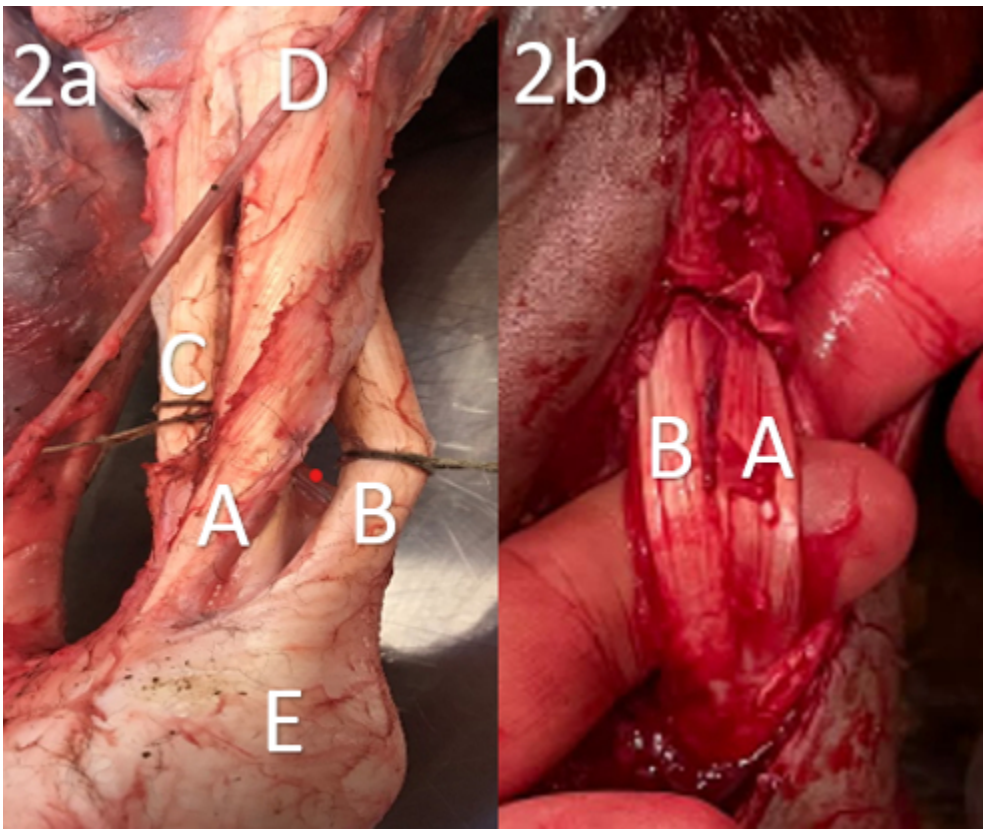

Figure 2a: Dissected version of surgical area with landmarks. (A) Superficial tendon of the medial head of the gastrocnemius muscle. (B) Superficial digital flexor tendon. (C) Deep tendon of the lateral head of the gastrocnemius muscle. (D) Lateral saphenous vein. (E) Calcaneus. Figure 2b: The superficial tendon of the medial head of the gastrocnemius muscle and the superficial digital flexor tendon can look similar during surgery, and were distinguished using the methods described above. Note in this incision that was made proximally, how the location of both tendons changes in comparison to their distal location seen in Figure 2a.

218x183mm (57 x 57 DPI)